Evolution of environmental policies and asset values: nutrient trading schemes in The Netherlands

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Abstract

In 1986 the Dutch government started to regulate animal agriculture through the imposition of the phosphate based manure production rights (quotas). Mandatory production control programs affect asset values. Capitalization theory postulates the value of any asset is equal to the present value of its expected future returns. We estimated a reduced form derived land demand model using pooled cross section-time series data. The results show the phosphate quota system increases the price of agricultural land in the surplus region where the quota is binding but not in the deficit region where the quota is not binding. Second, the increase in the cost of environmental compliance in the surplus region relative to that in the deficit region generated an eroding effect on the existing gap in the land rents and consequently land prices between regions.

Keywords: land prices, land use, production quotas

1. Introduction
In 1986 the Dutch government started to regulate animal production through the imposition of phosphate based manure production rights (quota). There are two parts to the quota: land based quota and animals based quota. In the 1986-1994 period the only way to acquire manure production rights was through acquiring land. In 1994 animals based quota became tradable but under regionally differentiated constraints. Mandatory supply control programs such as production quotas affect asset values, particularly land prices. Capitalization theory postulates the value of any asset is equal to the present value of its expected future returns. Temporal and spatial variation in environmental regulation may influence these returns and, hence, land prices.

The welfare implications of mandatory supply programs in agriculture have been extensively studied in the literature. For example, Rucker and Thurman (1990) have studied the U.S. peanut program whereas Babcock and Foster (1992), and Rucker, Thurman and Sumner (1995) have studied the tobacco production rights. However, there are only several instances where the impact of mandatory supply programs or other types of government regulation on agricultural land values have been addressed. Vantreese, Reed and Skees (1989) study the case of burley tobacco quotas and also review most of the older literature in this area dating back to the late 1960s. Schoemaker (1989) analyzes agricultural land values and rents under the Conservation Reserve Program. A relevant body of literature has also developed examining the effects of changes in environmental regulations on the location decisions of industries. There is no general consensus on the relative significance of this effect. Some studies have found evidence that increased regulation can significantly influence industry location (Henderson, 1996) while other studies have found little significant evidence of such an effect or that the effect occurs only in cases were regulation is extremely severe (McConnell and Schwab, 1990). Finally,
studies testing the accuracy of the capitalization formula in land markets are numerous (e.g. Burt, 1986; Falk, 1991; Clark, Fulton and Scott, 1993) and the results are mixed.

The objective of this paper is to analyze the development of environmental policy for intensive animal production in the Netherlands over the period 1988-1996 and its impact on agricultural land values. More specifically the purpose of our study is twofold. First, we intent to test that quota systems with regional constraints on trading introduce spatial differences in the returns of agricultural production. When this spatial difference is maintained over time, the differences in rents capitalize into farmland values. Second, we analyze the effects of environmental compliance costs in the context of a regionally restricted quota trading system. It is hypothesized that land values in the centers of animal production decline with higher compliance costs. In contrast, in other regions an increase in land prices can be expected.

The outline of this paper is as follows. Section 2 gives an overview of the institutional setting for animal production in the Netherlands. Section 3 presents a straightforward conceptual model leading to an estimation of a single equation model relating land values to farm income and environmental compliance costs, with additional variables included to account for regional heterogeneity. Empirical results are presented and discussed in section 4. Finally, Section 5 gives the main conclusions.
2. Institutional setting

Since the enactment of the Meststoffenwet on January 1, 1987, Dutch legislation allows a total manure production from all animal sources of up to 125 kg of phosphate (P$_2$O$_5$) per hectare of land. Farmers producing more manure in terms of phosphate need additional registered animal based manure production rights.

The system of manure production rights (manure quota) was introduced in two steps: in 1987 for the production of manure from cattle, swine and poultry, and in 1992 for the production of manure from sheep, goats, ducks, foxes, nutria and rabbits. Each farm was ascribed a “reference amount” based on an inventory of animals numbers and standards$^1$ for the manure production for each specific animal category measured in kg P$_2$O$_5$ per year$^2$. On Dec. 31, 1986 (and again on Dec. 31, 1991), all land either owned or on longer term lease (minimal 6 years and officially registered) used for agricultural purposes was assessed too. The difference between the reference amount and the assessed acreage based phosphate rights was used to establish a distinction between manure surplus farms (with manure production in excess of 125 Kg of P$_2$O$_5$ per hectar) and manure deficit farms (with phosphate production below 125 Kg/ha). A deficit farm can still increase animal production on the basis of unused land based manure production rights. For a manure surplus farm such an increase in production capacity is only possible with an increase in the reference quantity of manure production rights.

Period 1986-1993: only trading in land related manure production rights

$^1$ These standards were calculated as the difference between phosphate supply (in feed, animals, fertilizer etc.) and phosphate removal (in meat, milk, eggs, animals, etc.). This residual is assumed to be the phosphate in manure.
From 1986 until 1994 the transfer of the manure production rights was severely restricted to prohibit a further exacerbation of the manure problem. The conditions under which transferring the quota was possible are given in the “Relocation Decision” enacted on May 1, 1987. It states that the reference quantity is transferable:

- as part of the transfer of a whole farm;
- with marriage and heritage;
- with the annulment of a lease contract for a farm, in which case the lessor was entitled to transfer the reference amount to another farm in his possession.

The limited possibilities for the increase of manure production rights on the farm and hence, production capacity, meant that expansion of an animal farm could have been only realized by means of land transactions. However, buying an additional hectare of land would result in a net increase in aggregate (animals plus land) manure production rights only for a deficit farm. For a surplus farm, buying one additional hectare of land would simply cause 125Kg of the existing reference (animals based) quota to “sink” into the land based quota with no net increase in aggregate manure production rights. So in fact, more animal production was possible only by starting a new animal farm or an animal enterprise completely on non-used land quota, that is by relocating animal agriculture to crop farming regions. Expansion of existing livestock farms in the Netherlands came to a standstill in the regions where animal production has been traditionally concentrated, that is, in the South and East of the country. Hence, the regulation indirectly caused a freeze of the agricultural structure.

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2 For the assessment of the number of animals different dates were used: December 31, 1986 for pigs, poultry and cattle, and December 1991 for sheep, goats, rabbits, ducks, foxes and nutria. (Amvb Registratiebesluit dierlijke meststoffen Stb. 625, 1986).

in those regions hampering the adaptation and investment processes required for solving the national manure problem. To counteract these limitations the “Law regulating transfer of manure production rights” was enacted January 1, 1994.

Period 1994-1997: Free trading in manure production rights

Main element of the ‘Law regulating transfer of manure production rights’ was that animals based manure production rights became tradable. For each farm the reference amount was converted into “manure production rights” (manure quota) to indicate the change in policy. In contrast to the homogeneous reference amount, manure production rights became highly differentiated to restrict the trading. This was done in three steps.

First, a farm’s total manure quota was officially divided into two parts: land based part and non-land based part. The first part amounts to 125 kg of P$_2$O$_5$ times the number of hectares of land on the farm, whereas the non-land based part is calculated as the difference between a farm’s reference amount and the land based quota.

Second, a farm’s non-land based quota is allocated to specific animal categories reflecting the situation on an individual farm. Using the inventory figures on animals from earlier assessments of the reference amount, each farm’s total manure quota (divided into the land-based part and the non land-based part) was partitioned into animal categories. This was accomplished by using a ranking scheme reflecting the extent to which keeping various categories of animals is truly land related. Three classes were established: (1) cattle and turkeys, (2) sheep, goats, foxes, nutria and ducks, and (3) pigs, chickens or broilers, meaning that cattle and turkey

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4 Under two important restrictions: the amount could only be bought and sold in its totality and the farm had to be continued as an autonomous enterprise at the same location as before.
raising was considered to be most distinctly land related. As the result of this rule, larger part of the non-land based, tradable, quota became allocated to pigs and chickens (see Table 1).

**Table 1. Example of the assessment of the tradable animal based quota**

Farm description:
- 9 hectares of land
- Reference amount 2800 kg P₂O₅, of which 800 cattle & turkeys and 2000 pigs & chickens
- Highest actual manure production in 1988-1990: 2200 kg P₂O₅, of which 500 cattle & turkeys and 1700 pigs & chickens

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Total</th>
<th>cattle &amp; turkeys</th>
<th>pigs &amp; chicken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference amount</td>
<td>2800</td>
<td>800</td>
<td>2000</td>
</tr>
<tr>
<td>Land related quota (9×125)</td>
<td>1125</td>
<td>Allocation 800</td>
<td>325 (1125-800)</td>
</tr>
<tr>
<td>Non land related</td>
<td>1675</td>
<td>0</td>
<td>1675</td>
</tr>
</tbody>
</table>

| Highest realized manure production | 2200 | 500              | 1700           |
| Land related 9×125                | 1125  | Allocation 500   | 625 (1125-500) |
| Non-land related (tradable)       | 1075  | 0                | 1075           |

| Dormant (non tradable) 1075       | 600   | 600 (1675-1075)  |

Third, the non land-based quota allocated to cattle, turkeys, pigs and chickens (broilers) is differentiated further to account for the improvements in feed conversion in these sectors. For each of these animal categories a “dormant manure production” is assessed, that is the difference between the original reference amount and the actual manure production⁵. This is done for each farm individually. Dormant manure production is determined from the difference between the realized manure production and the land related quota.

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⁵ Information on the actual manure production for each surplus farm is available from the annual manure bookkeeping accounts. This bookkeeping system was introduced together with the establishment of the reference amount to ensure that actual phosphate production does not exceed the reference amount and to check manure application rates (see Breembroek et al., 1996). To assess a
production represents quota that is no longer used; therefore this part of the quota is not tradable (see Table 1). Finally, there is a 25% reduction when the resulting maximally transferable animal based quota is actually sold. This reduction applies to all animal categories.

Besides through trading in animals based rights, manure quota can still change hands through land transactions (lease or sale). As before, if additional land is acquired by a surplus farm, the land-based quota that goes with it automatically ‘sinks’ into the animals based quota. So, for a surplus farm, acquiring more land reduces the tradable part of the quota by increasing the land-related share and reducing the non land-related share of the total manure production rights.

*Trading restrictions*

Trading of the animals-based manure quota is geographically restricted. Transferring quota is allowed within regions and from a surplus region into a deficit region, but prohibited from a deficit region into a surplus region. Moreover, trading is also restricted across certain animal species (see Table 2). For example, if the farmer wants to increase swine production he has to acquire the same quota category (pigs and chickens) since transferring phosphate quota from any other animal category to pigs is not permissible. The farmer who acquires additional manure production rights has to certify that he has either sufficient land on his own farm to dispose off the total manure for the next two years or has a manure disposal contract with another farm.

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dormant manure production rights for cattle, poultry and pigs, the highest manure production figures are selected from the three year period: 1988-1990.

6 There two manure surplus regions in the Netherlands: East (Gelderland and Overijssel) and South (Noord-Brabant), where, historically, most of the animal agriculture was located. These regions are characterized by average manure production of more than 125 kg of P₂O₅/ha.
Table 2. Change rules for animal based quota

<table>
<thead>
<tr>
<th>Change From/to</th>
<th>Cattle</th>
<th>Turkey</th>
<th>Chicken</th>
<th>Pigs</th>
<th>Sheep</th>
<th>Other animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Turkeys</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chicken</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pigs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sheep</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other animals a</td>
<td>No c</td>
<td>No c</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

a Goats, Foxes, Nutria, Ducks, Rabbits.
b Till January 20, 1995. After this date substitution was allowed.
c Till February 1, 1995. After this date substitution was allowed.

Another environmental regulation targeting farmers willing to expand animal production in the concentration areas is the requirement to acquire additional ammonia rights. Trading in ammonia rights is even more spatially restricted than trading in manure production rights. It is only allowed within a county. There is no ammonia quota regulation in the manure deficit regions. For animal farmers in the concentration areas, particularly for those who want to expand their production, relocating their enterprise or starting a second farm in the non-concentration areas has become an attractive alternative due to the significant difference in costs of environmental compliance between the two regions (see Figure 2).

3. The conceptual model

To model this extremely complicated institutional arrangement, several necessary simplifying assumptions are necessary. As will be seen later, most of these are quite innocuous and should not influence the final conclusions. We will assume the presence of one type of animal production (say swine) which is regulated through a mechanism of mandatory supply control program in the form of phosphate ($P_2O_5$) based
manure production rights (quota). To keep or grow a certain number of pig ($Y$), each farmer $i$ must possess a manure quota ($M$) expressed in Kg of $P_2O_5$, which consists of the animal-based ($A$) and land-based ($L$) components:

$$\begin{align*}
M_i &= \alpha Y_i \leq A_i + kL_i,
\end{align*}$$

Each hectare of agricultural land carries with it $k=125$ Kg of $P_2O_5$. In addition, a farmer can own a historically determined animal based quota $A_i$ valid for certain number of animals, with the relationship between animals and phosphate being determined by the animal specific transfer coefficient $\alpha$ (e.g., 7.4 Kg of $P_2O_5$ for one fattening pig per year). Land-based component of the quota is tradable only through the land transactions (sales and leasing) whereas the animal based quota is separately tradable with some restrictions on regional transfers.

We will assume the existence of two different yet internally homogeneous geographical regions. Region 1, the manure deficit region, has higher cost swine producers and the quota is not binding at the regional level. The expansion can occur through bidding the land away from other agricultural uses. Region 2, the manure-surplus region, has lower cost producers and the aggregate phosphate quota (land plus non-land) is binding at the regional level, so that no net-expansion at the regional level can occur. We also assume that trading of quota is permissible within regions but not between regions. As a matter of fact, the phosphate quota trading rules in the Netherlands allow the quota to be traded from a surplus region into a deficit region but not the other way around. However, as we will show shortly, the stated assumption is not restrictive at all, because the direction of quota transactions that we ruled out, given the existing differences in quota allocations and marginal costs of production, would have never happened anyway.
Following the approach by Babcock and Foster (1992), consider a situation in which an animal-based phosphate quota for the region is initially distributed to the local producers. Each producer received a quota corresponding to the number of animals on his farm at a given point in time. Once allocated the aggregate quota cannot be increased, such that $\sum A_i = A$. The $i^{th}$ producer may lease in (buy) additional quota $a_i > 0$ paying an annual rental rate of $r$ per unit, or lease out (sell) some or all of the initial endowment of quota $A_i \leq a_i < 0$ receiving $r$ per unit. Each producer is also endowed with some agricultural land. The producer can lease in (buy) additional land $l_i > 0$ paying an annual per unit rental rate $w$ and acquiring with it the corresponding land based quota or lease out (sell) some or all of the land $L_i \leq l_i < 0$ surrendering its land based quota together with it. The aggregate land supply in the region is fixed, such that $\sum L_i = L$. The producer simultaneously chooses a level of output, quota and land so as to maximize profits, subject to the phosphate quota constraint:

$$\underset{Y_i, l_i, a_i}{\text{Max}} \pi_i = PY_i - C_i(Y_i) - wl_i - ra_i$$

s.t.

$$(A_i + a_i) + k(L_i + l_i) \geq \alpha Y_i$$

where $\pi_i$ is an individual farmer’s profit, $Y_i \geq 0$ is his output level, $P$ is the output price, $C_i(Y_i)$ is a farmer specific non-land cost function with increasing marginal costs ($C_i' > 0$, $C_i'' > 0$). The optimal choice of decision variables may be characterized by the Kuhn-Tucker conditions:

$$P - C_i'(Y_i) - \alpha \lambda_i \leq 0$$

(3)

$$\left[ P - C_i'(Y_i) - \alpha \lambda_i \right] Y_i = 0$$

(4)
Competitive market equilibrium is characterized by rental rates for quota \( r \), land \( w \), and output price \( P \), such that all markets clear and the total level of production does not exceed the available manure quota:

\[
\sum_i a_i = 0 \\
\sum_i l_i = 0 \\
\sum_i Y_i = D(P) \\
\sum_i Y_i \leq \sum_i \frac{A_i + kL_i}{\alpha} = \overline{M}
\]

In expression (13), the residual demand schedule facing producers in the region is labeled as \( D(P) \). In equilibrium, the product price is such that all producers’ (with positive levels of production) marginal costs are mutually equal and equal to the difference between the price and the quota rental rate corrected for the transfer coefficient \( \alpha \), or the difference between the price and the land rental rate corrected for the \( \alpha/125 \):

\[
C_i'(Y_i) = C_j'(Y_j) = \left( P - \alpha r \right) = \left( P - \frac{\alpha}{k} w \right)
\]

Figure 1 illustrates the determination of lease rates and production levels in two regions with different production costs when there is a quota trading within but not
between regions. It is assumed that the residual demand curve facing each region is perfectly elastic at price $P$. Region 1, a deficit region, is endowed with an aggregate phosphate quota level $M_1$ such that the marginal cost of animal production (say hogs) at $M_1$ is greater than the output price: $MC_1(M_1) > P$. As a result, the quota lease rate, either through acquiring more land or through purchasing animal based quota directly, is zero and the optimal production level is $Y_1^* < M_1$ (i.e., the quota is initially non-binding).

Region 2, the surplus region, has lower costs producers who can produce their aggregate quota $M_2$ at the marginal costs less than the output price: $MC_2(M_2) < P$. In this case, the entire quota is produced and the lease rate for quota is $r = \frac{1}{k} = \frac{P - MC_2(M_2)}{\alpha}$. The difference in rental rates can persist if quota cannot be transferred between the two regions (Rucker, Thurman and Sumner, 1995).
Figure 1: Effects of limited transferability of phosphate quota on rental rates and production levels.
Now assume that there is an increase in the price of one input into hog production in Region 2, while the price of the same input in Region 1 remained unaffected. A change in input prices alters marginal cost at all levels for which the input is used. This situation is depicted by an upward shift in the $MC_2$ schedule to $MC_2'$. As a result, the higher marginal cost curve intersects the still binding quota level $M_2$ at $MC'(M_2)$, and the resulting quota and land rentals shrink from $r$ to $r'$.

This is exactly what happened in the last several years with the Dutch hog production in the surplus region. With newly introduced regulation on ammonia emissions and increasing difficulties with the disposal of animal waste, the price of environmental compliance went up. The loss in profits due to an upward shift in marginal cost serves as an incentive for the lower cost producers to move their production into a deficit region as long as they can keep their marginal cost at the new location below $MC_2'$. Notice that despite the fact that animal based quota can be transferred from the surplus region into the deficit region, due to the differences in quota rentals these kinds of transactions would never occur. The manure production rights needed to expand the swine production in the deficit region will come entirely from the land-based quota. The influx of newcomers would bid up the land rents in the region causing some of the land to be converted away from other competing agricultural uses, notably the crop farming.

As with target price and acreage reduction programs in agriculture, the impact of mandatory production control programs on land values depends on their net effect on expected farm income and returns to land. The question becomes how big is the increase in land returns over the next best alternative and how long will it last. At the heart of the literature on land values is the asset pricing theory. The simplest version of this theory assumes that land buyers are risk neutral, they discount the future at the
constant rate $\delta$, markets are perfectly competitive, and land is valued only for its economic return. If these assumptions hold, then a precise relationship exists between land values and the income from that land. Asset pricing theory postulates that the value of the land is equal to the discounted present value of its expected future returns. The model explains the variation in land values through differences in land characteristics, which determine, in part, the expected future returns or rent-earning ability of that land.

Following capital asset pricing approach to land value formation, two testable hypotheses can be derived from a simple 2-regions model presented earlier. First, the existence of mandatory production control program should have increased the price of agricultural land in the surplus region where the quota is binding but not in the deficit region where the quota is not binding. Therefore, other things being equal (soil quality, access to markets, etc.), we should observe higher land prices in the surplus region than in the deficit region. Second, the increase in the cost of environmental compliance in the surplus region relative to that in the deficit region should have generated an eroding effect on the existing gap in the land rents and consequently land prices between regions.

The first hypothesis is easily verifiable by simply inspecting the regional data on land prices. In order to test the second hypothesis, we estimated a reduced form derived land demand model using regional time series data. The behavior of land rents (prices) was explained by the regional variables measuring the total available agricultural land, number of farms, farm income, aggregate manure (phosphate) production, and the cost of environmental compliance. We anticipate the sign of land acreage variable to be negative reflecting the negative price-quantity relationship. The expected signs of the number of farms and income variables are positive indicating a stronger demand pressure on the fixed supply of land if there are more households in the region and when
times are prosperous. The expected sign of the phosphate variable is positive reflecting the historical gap in land prices between manure surplus and manure deficit regions. Finally, we anticipate the sign of the environmental compliance cost coefficient to be negative indicating the squeeze that the increase in the environmental cost imposes on the land rents and consequently land prices.

4. The Data

The empirical analysis was carried out using data at the provincial level. The entire data set had 81 observations; 9 years (1988-1996) and 9 provinces (Groningen, Friesland, Drenthe, Overijssel, Gelderland, Noord-Holland, Zuid-Holland, Zeeland and Noord-Brabant. Annual data on land prices are weighted (by acreage sold) average prices paid for cropland and grassland by province (CBS, Statistiek Overdrachten en Verpachtingen van Landbouwgronden, various years). The effects of non-agricultural factors on farmland values are excluded; the data source used covers only land transactions for permanent agricultural use. The source also excludes sales among family members known to be ‘soft deals’. Official statistics is also available on land rents both for grassland and cropland by province and year. However, this information was considered unusable owing to the fact that the Netherlands strictly regulates long term leasing arrangement so the observed rental rates do not reflect the true opportunity cost of land. Instead, ‘free market’ rental rates were constructed by multiplying the observed ‘arms-length’ land prices with the average annual mortgage rates used by agricultural banks (CBS, Landbouwcijfers, various years).

Information on annual farm income is available in great detail (LEI-DLO, Bedrijfsuitkomsten in de Landbouw, various years). However, the classification used
is based on farm types and sizes by agronomic production conditions and does not parallel the distinction by provinces. The farm income data used for the provinces Groningen, Drenthe and Zeeland are those of the most frequently observed farms in the three province: large crop farms on northern clay soil (Groningen), southern clay soil (Zeeland) and on sandy soil (Drenthe). Data for the other 6 provinces reflect the annual income of a representative farm based on the provincial composition of farms in 1993/94 (LEI-DLO, Bedrijfsuitkomsten in de Landbouw, 93/94, p. 16-17). For Overijssel, Gelderland and Noord-Brabant the income of the representative farm is composed of the income of large pig farms (50%) and large and small diary farms (35 and 15%), all these farms are on sandy soil. For the remaining three provinces the representative farm is made up of larger and smaller dairy farms (80% and 20%).

The cost of environmental compliance in Dutch agriculture includes mainly the costs of animal waste disposal, the cost of extra animal waste storage capacity and the tax on manure surplus. Among these costs, the animal waste disposal cost is most important (Van Riesen, 1996). Data on the annual cost of animal waste disposal is available as a percentage of farm income by farm type and year for 1989-1994 (LEI-DLO, Landbouw, milieu en economie, Periodieke Rapportage no. 68, Ed. 89, 91 and 92). Cost of waste disposal in 1985 and 1986 was assumed zero, as waste disposal become only compulsory in 1987. The data for 1987 and 1988 was extrapolated from the farm level data for 1989 using the annual change in cost of animal waste disposal at the national level (Van Riessen, 1996). The same source was used to extrapolate the farm level data for 1994 to obtain costs for 1995 and 1996.

7 This tax was introduced to finance the Mestbank, a governmental organization responsible for improving animal waste distribution to the crop farming regions.
To measure the importance and the size of agriculture in various regions we used three variables: total land devoted to agriculture, number of farms, and the number of animals. Total agricultural land variable includes the total acreage of grassland and cropland (CBS, Landbouwtelling, various years). From the same source we used the data on the total number of agricultural enterprises. To account for the intensity of animal production, we used the total phosphate production. This figure was calculated by multiplying the number of animals by the coefficients that convert animal numbers into kilograms of phosphate. Detailed data on animal numbers by provinces is provided by the annual farm surveys.

All monetary variables (land prices, land rents, farm income and costs of environmental compliance) are in constant 1990 Guilders (PPP was taken from CBS, Landbouwcijfers, various years).

5. The Empirical Results

Using the available cross-regional and time series data, two linear regression models were estimated, one with the land rent as a dependent variable and one with the land price as a dependent variable. The estimation results are summarized in Table 3. Both models have the same structure with the only difference being the mortgage rate, which was included in the price model as an explanatory variable, whereas in the rent model it was used to multiply the price thereby becoming a part of the dependent variable.

Table 3: Regional land price (rent) model estimation results:

<table>
<thead>
<tr>
<th>Variable/ Model</th>
<th>Land rent</th>
<th>Land price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adj. $R^2=0.7330$</td>
<td>Adj. $R^2=0.7959$</td>
</tr>
<tr>
<td></td>
<td>Coefficient 1</td>
<td>Coefficient 2</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Intercept</td>
<td>2,476.2 **</td>
<td>38,547 **</td>
</tr>
<tr>
<td>Total acreage</td>
<td>-0.010815 **</td>
<td>-0.11964 **</td>
</tr>
<tr>
<td>Income</td>
<td>0.016302 **</td>
<td>0.17208 **</td>
</tr>
<tr>
<td>Phosphate production</td>
<td>0.000029 *</td>
<td>0.000296 *</td>
</tr>
<tr>
<td>Environmental cost</td>
<td>-0.049639 *</td>
<td>-0.014856</td>
</tr>
<tr>
<td>Number of farms</td>
<td>0.044711 *</td>
<td>0.67652 **</td>
</tr>
<tr>
<td>Mortgage rate</td>
<td></td>
<td>-94,277</td>
</tr>
<tr>
<td>Region</td>
<td>1,214.3 **</td>
<td>9,436.8 **</td>
</tr>
</tbody>
</table>

*) significant at 5%; **) significant at 1%.

Given the fact that the relationship between farm income and land prices or rents is most likely not contemporaneous, the income variable included in the regression model was constructed as a 3-year moving average lagged one period. For example the income influencing the land price in 1988, the first year in our sample, is the average of farm incomes in 1985, 1986 and 1987. Similarly, the cost of environmental compliance was also lagged one period.

In addition to explanatory variables whose presence in the model was justified earlier, we also included a dummy variable defined as 1 if the province belongs to the manure surplus region and 0 if it belongs to the manure deficit region. The variable coefficient ended up being positive and significant indicating that there are still measurable differences in land prices between the two regions not explained by the binding versus non-binding manure production quota. The price differences may be explained by the differences in soil productivity, access to markets, etc. The reason for not explicitly modeling factors such as urban pressure or location, are twofold. First, due to the strict zoning regulations and extremely high capital gains tax in the Netherlands, agricultural land is exposed to a much smaller urbanization pressure than one would expect given the population density of the country. Since it is extremely
difficult to convert agricultural land into other uses, such as commercial or residential, demand for agricultural land comes mainly from agriculture. Therefore, the possibility of bidding away agricultural land by other more profitable sectors can be assumed away. Second, the country is so small that locational differences manifested in terms of higher or lower transportation costs are virtually irrelevant.

Both models fit the data fairly well with adjusted coefficients of determination of 73% and 80% respectively. In both models all variables have the expected signs. In the rent models all coefficients are significant at the standard levels, whereas in the price model, the cost of environmental compliance and the mortgage rate are insignificant.

5. Conclusions

Mandatory supply control programs such as production quotas affect asset values, particularly land prices. Capitalization theory postulates the value of any asset is equal to the present value of its expected future returns. Temporal and spatial variation in environmental regulation may influence these returns and, hence, land prices. The objective of this paper is to analyze the development of environmental policy for intensive animal production in the Netherlands over the period 1988-1996 and its impact on agricultural land values.

Following capital asset pricing approach to land value formation, two testable hypotheses were derived. First, the existence of mandatory production control program should have increased the price of agricultural land in the surplus region where the quota is binding but not in the deficit region where the quota is not binding. Second, the increase in the cost of environmental compliance in the surplus region relative to that in the deficit region should have generated an eroding effect on the existing gap in the land rents and consequently land prices between regions.
In order to test the hypotheses, we estimated a reduced form derived land demand model using pooled cross section-time series data. The behavior of land rents (prices) was explained by the regional variables measuring the total available agricultural land, number of farms, farm income, aggregate manure (phosphate) production, and the cost of environmental compliance. The results show the phosphate quota system leads the higher land prices (and quota prices) in the regions where the quota is binding. This creates a capital asset for sitting tenants but involves an additional cost for new tenants or those who wish to expand. It thus represents an impediment to structural change in the industry, particularly in the development towards larger farms capable of carrying out substantial environmental investments.

With newly introduced regulation on ammonia emissions and increasing difficulties with the disposal of animal waste, the price of environmental compliance in the manure surplus region went up. The loss in profits due to an upward shift in marginal cost served as an incentive for the lower cost producers to move their production into a deficit region. The influx of newcomers bid up the land rents in the region eroding the existing gap in land values between regions.

References


